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Anatomical connectivity networks of the human brain

Milja Asikainen

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Ohjaaja: *Raj Kumar Pan*

Valvoja: *Harri Ehtamo*

Systeemianalyysin laboratorio

Background

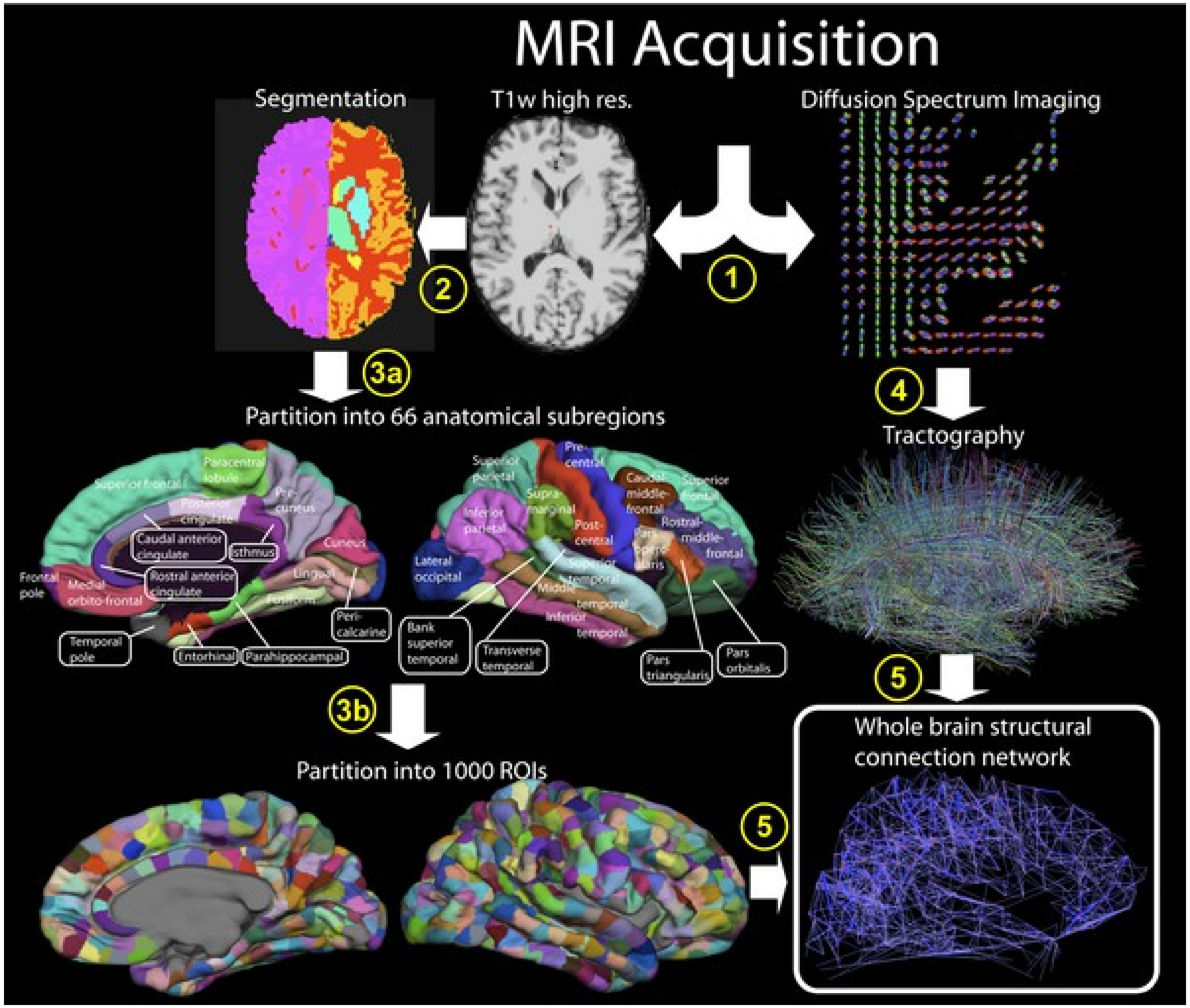
- The human brain is a large complex interconnected system
- Brain consist of neurons (gray matter) and myelinated axons (white matter)
- Recently it has become possible to map the anatomical connectivity patterns of the human brain in vivo

Main goals

- Construction of cortical anatomical networks from preprocessed Diffusion Tensor Imaging (DTI) data
- Construct networks from preprocessed functional Magnetic Resonance Imaging (fMRI) data
- Analyzing and comparing structural and functional networks using complex networks tools

DTI and fMRI

- DTI is a technique to detect the white matter tracts by observing the diffusion of water in the brain
- First part is to divide the brain into small areas (region of interest, ROI) and then compute the fiber density between the areas → weighted network
- FMRI measures brain activity by detecting changes in blood flow
- Calculating correlation between timeseries of different regions → weighted network



Hagmann, Cammoun, Gigandet, Meuli, Honey, Wedeen, Sporns:
Mapping the Structural Core of Human Cerebral Cortex (2008)

Tools and datasets

- Decoding Emotions -project of Aalto University Brain and Mind laboratory: DTI and fMRI for eight subjects
- Alexander Leemans: Good DTI data for 56 subjects. A subset of eight subjects was randomly chosen to make comparison with Dti data from Emotions project
- Tools: Pipeline for Analysing braiN Diffusion imAges (PANDA), MATLAB, NetworkX (python library)

Validation within DTI dataset

- 44 % of edges belong to all graphs
- For each node some properties were calculated. This was plotted against the average over the graphs
- Pearsson correlation coefficients were calculated

Degree	Clustering coefficient	Betweenness centrality	Eigenvector centrality	Closeness centrality
0.89	0.67	0.83	0.87	0.89

Cross validation between DTI datasets

- Pearsson correlation coefficients for node properties were higher for Alexander Leemans DTI data
- Average global graph properties were calculated

	Nodes	Edges	Clustering coefficient	Transitivity	Average shortest path lengths	Common edges
Emotions	86	375	0.49	0.42	0.82	44 %
AL	90	2011	0.66	0.63	0.49	53 %

FMRI networks

- FMRI data has edge between each node and deciding threshold to choose edges for a graph is not straightforward
- Pearsson correlation coefficients calculated for node properties of the graphs do not indicate that different graphs correlate

Degree	Clustering coefficient	Betweenness centrality	Eigenvector centrality	Closeness centrality
0.39	0.05	0.03	0.26	0.25

Comparing DTI and fMRI data

- Threshold for fMRI graphs were chosen so that number of edges of fMRI and DTI graphs for each subject were the same
- Global graph properties for each subject were calculated. Averages are in table below

	Nodes	Edges	Clustering coefficient	Transitivity	Average shortest path lengths	Common edges
DTI	111	523	0.49	0.41	0.80	43 %
fMRI	116	523	0.49	0.53	2.64	21 %

Conclusions

- DTI networks for Emotions project have some properties which suggest that networks for different subjects are somewhat similar
- Different DTI datasets are not similar
- Correlation between DTI and fMRI data was not found
- Building DTI and fMRI networks should be tried with other parameters

References

- Yan C, Gong G, Wang J, Wang D, Liu D, Zhu C, Chen ZJ, Evans A, Zang Y, He Y: Sex- and brain size-related small-world structural cortical networks in young adults: a DTI tractography study (2010)
- Decoding Emotions -project of Aalto university's Brain and Mind Laboratory
- Alexander Leemans (http://www.isi.uu.nl/People/Alexander/)